F.W. BELL

CURRENT/WATT SENSORS

PI SERIES

US $17 1-9 pkg.
Min $75.

FEATURES

- Senses ac/dc Current/Power
- Small Size, Lightweight
- Low Cost
- Wave Solderable
- Bi-Directional
- Fast Response
- Easy Installation

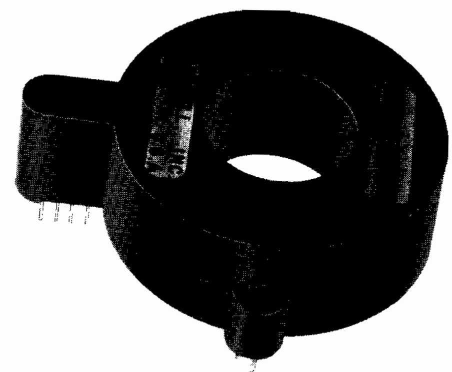
TYPICAL APPLICATIONS

- Replaces Shunts
- Overload Sensor in dc Power Supplies
- Control dc Motors
- Power Measurements in dc & ac Circuits
- Monitor and Control of Battery and Charge Circuits

DESCRIPTION

The PI Series Current/Watt Sensors are small, lightweight, low cost devices for current measurements up to 600 amps ac/dc and power measurements in which the maximum level is determined by the user's scaling resistor values.

Each sensor consists of a gapped toroidal core and a new, high-accuracy, high-reliability Hall generator located in the core gap. The components are encapsulated in a thermoplastic polyester case. The PI Series is designed so that minimal time is required for installation. Two mounting tabs and four circuit pins can be plugged directly into a PC board, and wave-soldered. Mounting hardware is not required. Electrical connections are made directly to the PC board, eliminating the necessity for time-consuming hand wiring.



Actual Size

CURRENT MEASUREMENTS

Each sensor requires an excitation of up to, but not exceeding, 40 mA. This excitation must be derived from a suitable external source. When properly excited, the sensors will provide an isolated output voltage directly proportional to the current passing through the aperture. The waveform of this output voltage is identical to the waveform of the measured current when the sensor operates with dc excitation.

The only coupling between the sensor and the current-carrying conductor is magnetic. This offers the advantages of complete isolation, no dc insertion loss, and a negligible ac insertion loss. The common problems associated with shunts (no isolation, power dissipation, and heating effects) are totally eliminated.

The PI Series consists of 3 models. Select the model that best fits the intended application. To perform current measurement, simply pass the current-carrying conductor through the aperture and apply the specified excitation (I_C) to PINS 1(-), 4(+). An output voltage accurately proportional to the measured current will appear at the output terminals. The polarity of the output voltage will be PIN 2(+), 3(-) if the current is flowing through the aper-

ture as indicated by an arrow on the case and the excitation is applied per the above polarity. Sensors may be operated with excitation at lower-than-rated levels. In this case, their sensitivities will be proportionally lower.

CAUTION: Excitation at more than 10% above the rated levels may cause damage to all of the models specified.

The excitation circuit and the output circuit are interconnected in the Hall generator. A common connection of these two circuits "outside" the sensor will short-circuit the Hall generator, adversely affecting the sensor operation.

Either the excitation circuit or the output circuit may be grounded, but not both. When feeding two or more sensors from a common excitation supply, the output circuits must be kept isolated from each other.

At zero measured current, an offset voltage may appear at the output terminals. This offset voltage can be substantially reduced by adjusting an external nulling circuit as shown in the schematic diagram Fig. 1

Current overloads (either continuous or transients) will not damage the sensors. Above rated current levels, the sensor sensitivity has a roll-off characteristic. Typically, at 1.3 F.S. current, the output error may amount to -10% F.S.

Hall-effect current sensing is a unique method of measuring electric current which offers many advantages. Some of these are non-contact operation, high degree of accuracy, dc and ac current measurement, ability to indicate direction of current flow, and low circuit loading.

Unlike a shunt, a PI Series sensor offers complete isolation, does not pose any power dissipation problems, and does not introduce a series load in the measured circuit. Unlike current transformers, which are limited to ac current measurement in a narrow frequency range, the PI Series sensors measure dc as well as ac currents in a wide frequency range.

MEASUREMENT THEORY

The PI Series current sensors operate on the principle of Ampere's Law which states that current in a conductor produces a proportional magnetic field surrounding the conductor. The PI Series sensors measure current accurately by sensing the strength of the generated magnetic field.

Each sensor contains a Hall generator mounted in a gapped toroidal core. The current-carrying conductor is passed through the core aperture. The core concentrates the magnetic field and passes it through the Hall generator.

The Hall generator is a magneto-sensitive semi-conductor that provides an output voltage proportional to the product of the magnetic field normal to its surface and the control current flowing through it. The control current is derived from the excitation supply. Since the control current is held constant the output voltage is proportional to the generated magnetic field. According to Ampere's Law this is also proportional to the current in the aperture.

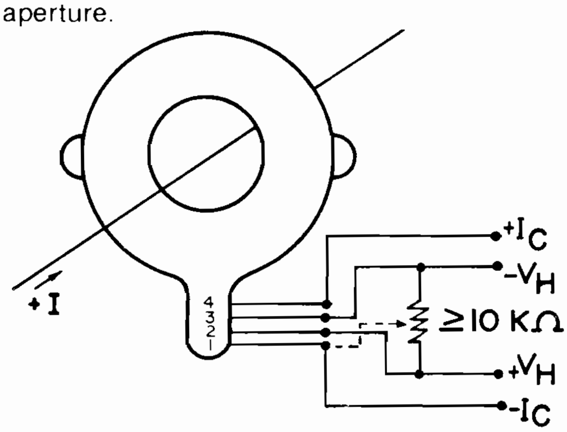


Fig. 1 Suggested Off-Set Nulling Circuit

Caution: Do not tie excitation circuit and output circuit to a common ground.

POWER MEASUREMENTS

Hall effect sensors provide an output voltage accurately proportional to the product of two dc or ac input currents. This characteristic makes the sensors applicable as a power-measuring device in systems operating with steady or pulsating dc power.

MEASUREMENT OF AC POWER

(P = V x I x COSΘ)

F.W. Bell current sensors can be used to provide a dc voltage output which is accurately proportional to Real Power. This is possible because of the multiplying ability of the Hall generator used in the current sensors.

Fig. 2 illustrates a typical schematic for a Real Power measurement application. The load current is sensed by passing the load-current-carrying conductor through the current sensor aperture, eliminating the need for a current transformer (CT). Hall generator excitation current (I_C) is derived from a step-down potential transformer (PT) and resistor (R). Other means

of developing I_C such as dropping resistors may also be used.

CAUTION: If dropping resistors are used in place of a transformer, the output will not be isolated from the line. If the load is at a high potential above ground, isolation may be required between the sensor output and the indicating device to prevent personal injury.

The Hall generators used in F.W. Bell current sensors require an excitation current of 0 to 40 mA for Real Power measurements. Resistor R_1 must be added externally for purposes of calibrating the sensor output.

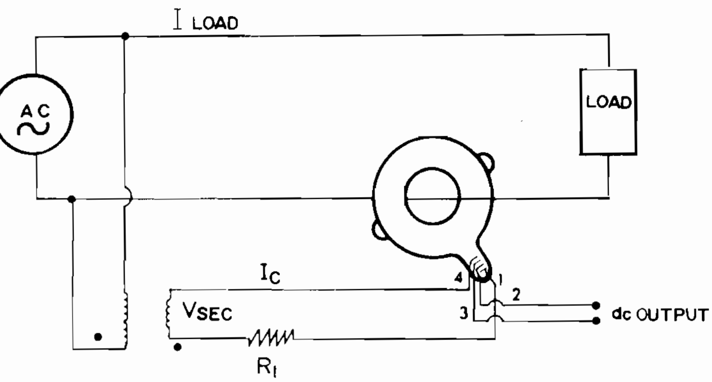


Fig. 2 AC Power Measurement

$$R_1 = \frac{V_{SEC}}{I_C} \qquad W_{R_1} = (I_C)\ (V_{SEC})$$

V_{SEC} = Maximum Anticipated Secondary Voltage

I_C = Maximum Anticipated Excitation Current. (Not to Exceed 40 mA).

W_{R_1} = Wattage Requirement for R_1

MEASUREMENT OF DC POWER
(P = V x I)

The output voltage of PI Series current sensors is accurately proportional to the product of the measured current and excitation current. This multiplying feature allows the PI Series sensors to be used as power measuring devices.

An example of this application is shown in Fig. 3. The circuit employs a PI Series current sensor which senses the proportional magnetic field when a current-carrying conductor is passed through the aperture. The circuit voltage is applied to the Hall input (I_C) of the sensor through a current-limiting resistor (R_1), causing a proportional current to flow through the Hall generator. As a result, an output voltage will be generated which is proportional to the product of line current and line voltage, therefore to line power.

CAUTION: Since output circuit and voltage input circuit of the sensor are interconnected in the Hall generator, the output circuit will have a potential to ground and can therefore not be grounded.

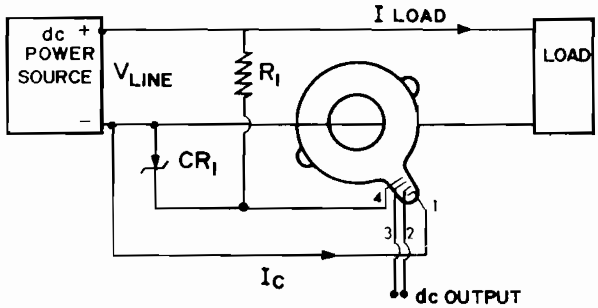


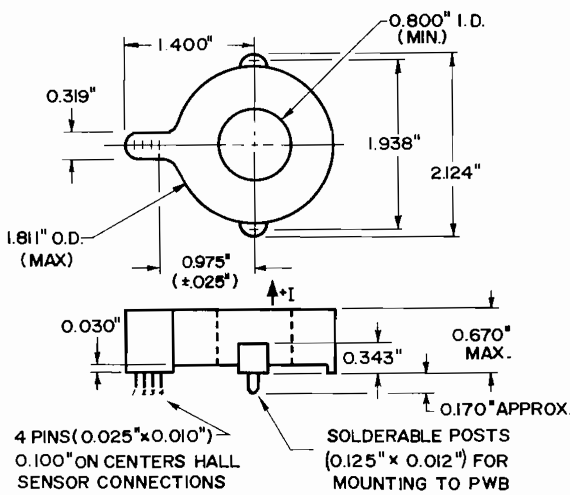
Fig. 3 DC Power Measurement

$$R_1 = \frac{V_{LINE}}{I_{C\ MAX}}$$

$W_{R_1} = (I_C)\ (V_{LINE})$

V_{LINE} = Maximum Anticipated Line Voltage

CR_1 = 24 V, $I_Z \cong$ 40 mA, 2 W



PIN IDENTIFICATION

1	$-I_C$	NEGATIVE CONTROL CURRENT
2	$+V_H$	POSITIVE OUTPUT VOLTAGE
3	$-V_H$	NEGATIVE OUTPUT VOLTAGE
4	$+I_C$	POSITIVE CONTROL CURRENT

PI SERIES

CURRENT/WATT SENSORS

SPECIFICATIONS

MODEL:	**PI-100**	**PI-350**	**PI-600**
Measuring Circuit			
Rated current, dc to ac peak	0 to ±100 A	0 to ±350 A	0 to ±600 A
Frequency range		dc to 1 kHz	
Inductance (1 turn)		0.1 μH	
Calibration level	100 A	32[illegible] A	525 A
Excitation Circuit			
Rated excitation I_C maximum		40 mA dc or ac rms	
Input resistance		30 to 120 Ω	
Output Circuit			
Sensitivity, V_H @ I_C = 40 mA minimum nominal maximum	0.5 to 1.1 mV/A	0.5 to 1.1 mV/A	0.25 to 0.55 mV/A
Calibration tolerance		±0.5% of reading	
Linearity, 0 to rated current	±1.5% F.S.	±1.5% F.S.	±2.0% F.S.
Response time to 99%		≤50 μs	
Source resistance		70 to 300 Ω	
Load resistance		≥10 k Ω	
Influences on Accuracy			
Zero current offset		≤±16 mV	
Excitation variation ±1%		±1%	
Temperature, ambient -40°C to 100°C		<-.07%/°C	
Close proximity of the return conductor		<0.25%	
Close proximity of ferrous metals		<0.15%	
Eccentric position of conductor in the aperture		<0.05%	
Withstand Capabilites			
Dielectric test between a bare ¾" diameter conductor thru the aperture and the sensor circuits		6 kV rms	
Output short or open circuit		No damage	
Weight, net		2.5 oz; 71 gr	

1½-2%

IH < 1%

Consult the factory about the availability of special models with other measured current ranges or other characteristics.

Specification subject to change without notice.

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